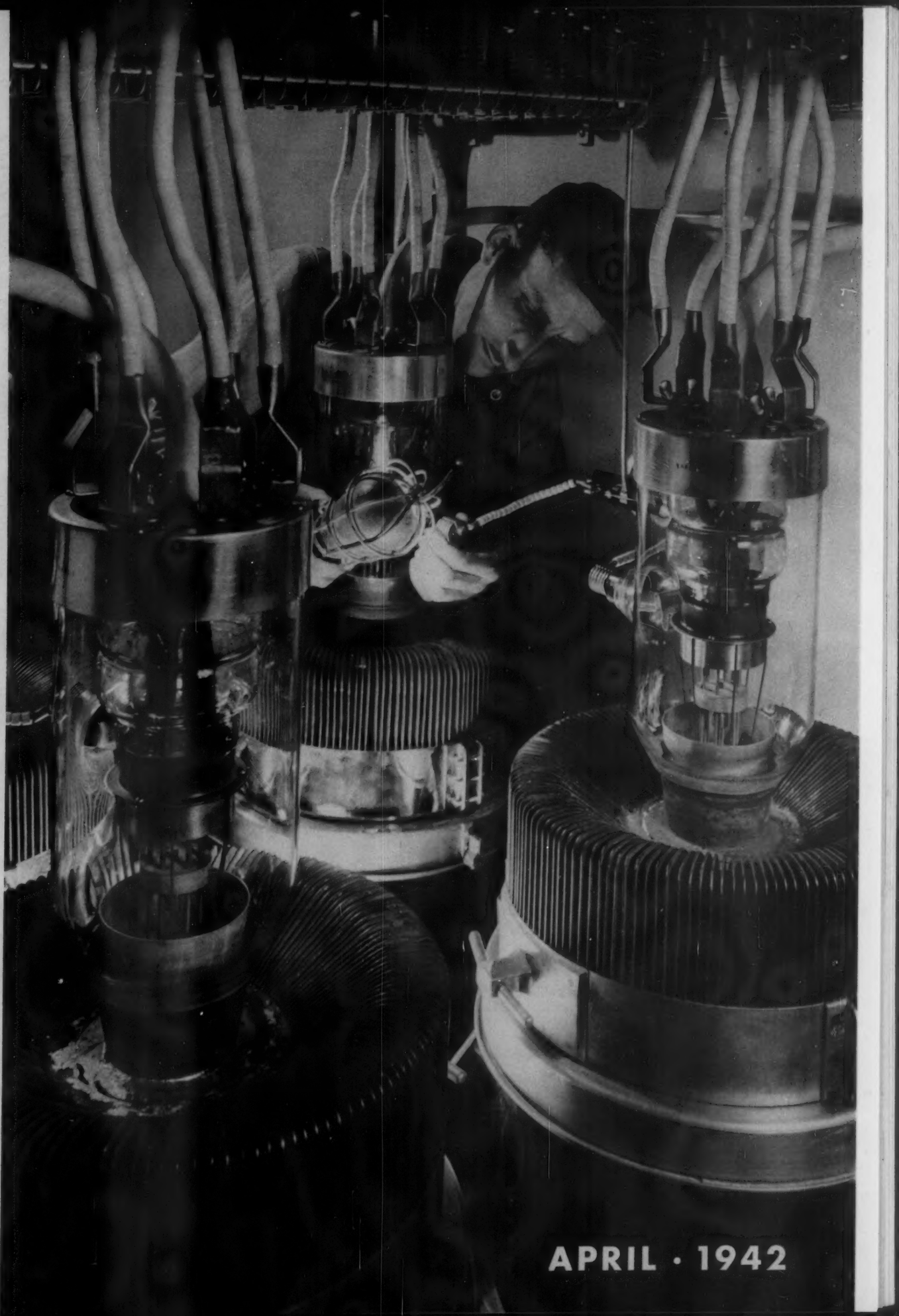
TECH ENGINEERING NEWS



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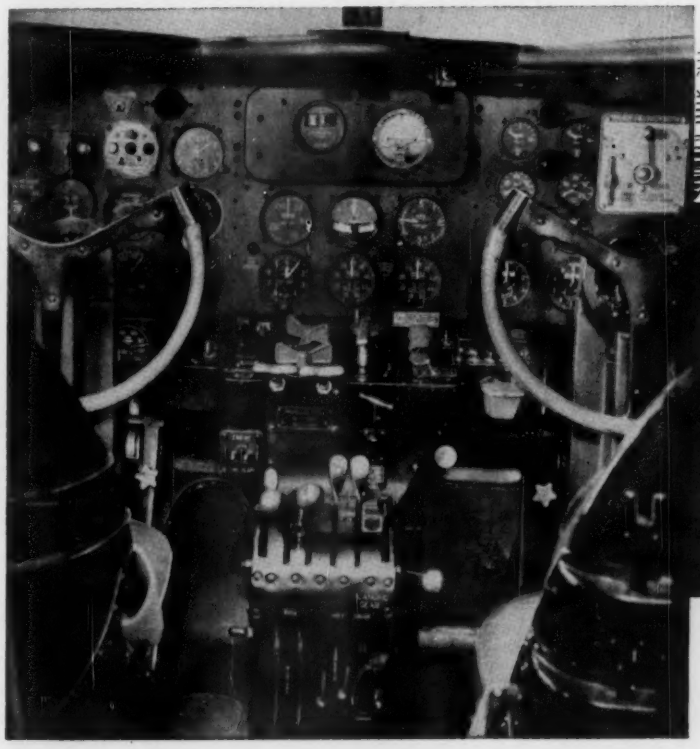

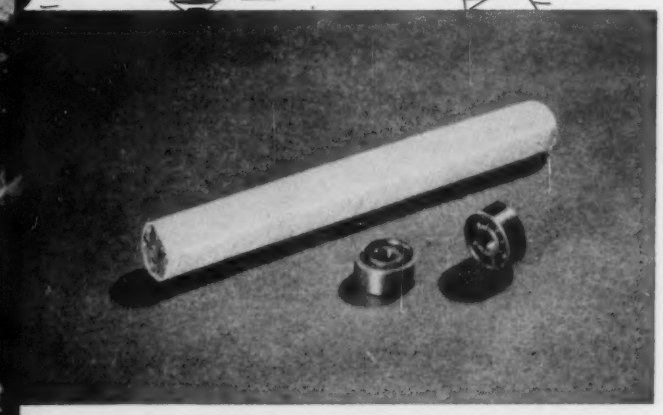

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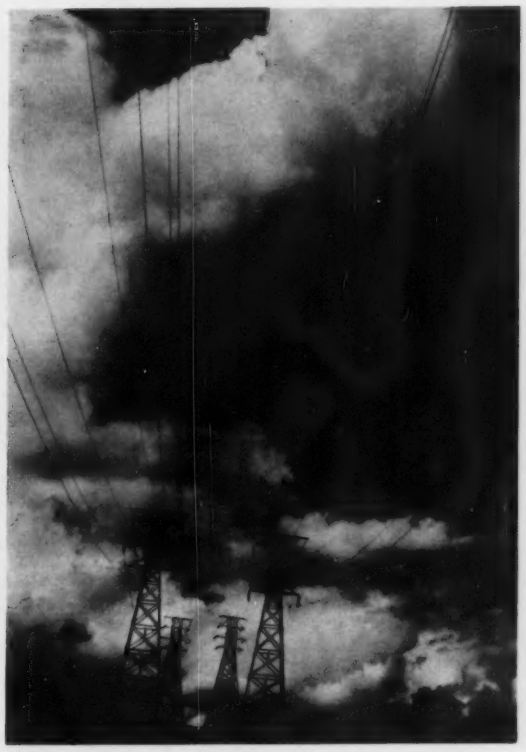

OUR COVER THIS MONTH
Air-Cooled Broadcasting Tubes

VOLUME XXIII
NUMBER 3

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NEW FIELDS FOR ELECTRICAL ENGINEERING

By ARTHUR R. VON HIPPEL

LABORATORY FOR INSULATION RESEARCH
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ELECTRICAL engineering today is essentially a science of classical concepts. Its fundamentals are Maxwell's equations formulating the properties of the electromagnetic field and its interaction with matter. The nature of matter enters only empirically into this discussion. We are told that conductors and insulators, magnetic and nonmagnetic materials exist, and that their numerical values may be found in tables.

This field and circuit theory is the "thermodynamics" of our profession. It formulates the overall balance of the electromagnetic phenomena, but their origin remains obscure. The chemical engineer is beginning to gain an understanding of the laws of thermodynamics through kinetic theory and statistics, and therewith is opening new horizons. The same is bound to happen to the electrical engineer in future years. Starting with the structure of matter, he will learn about the nature of the charge carriers, their distribution, and laws of motion. Macroscopic laws will be understood as the statistic result of atomic events. And, empowered with this insight, the engineer will intervene in the development and direct the process toward his own ends.

Why not leave the atomic side to the physicist? There is no real boundary between physics and electrical engineering. Our field is a branch of applied physics mainly concerned still with the applications of Maxwell's theory. While the physicist stood "clean" of such useful tasks and strove for insight, the electrical engineer built a new economy and talked in a new technical language appropriate for his tools. Thus the link between the two was wearing thin, until events forced both sides into closer coöperation. The physicist began to toss into the domain of the electrical engineer new instruments, such as thermionic tubes and photocells, rectifiers, thermistors, and fluorescent lamps, which could not be understood on the old classical basis. And the electrical engineer replied in kind with magic eyes, complex impedance bridges, high-frequency generators, high-voltage machines, and magnets for cyclotrons, which revolutionized the experimental technique of the physicist.

As a result of this upheaval, the fence between the two fields is falling into disrepair. The electrical engineer has to learn and to apply atomic physics in order to understand and improve his new tools, and the physicist is beginning to talk about "high Q's" and "characteristic impedances" — and seems to like it.

The Institute recognized this situation some years ago by creating the Laboratory for Insulation Research in the Electrical Engineering Department. Its activity is a good illustration of the problems and of the methods of attack characterizing the atomphysical branch of electrical engineering.

Take the case of the electric breakdown of insulators. It is one of the principal headaches of the design engineer that insulating materials will fail under excessive field intensities. Since no one knows what "excessive" is in individual cases — the breakdown values listed in tables are uncertain to several hundred per cent, and gained in a doubtful test procedure — equipment has often to be designed with an immoderate safety factor. It becomes bulky and expensive, while it might be cheap and streamlined and the keystone of new developments if we knew why an insulator breaks down and how its resistance might be strengthened.

In taking up this case, the Laboratory for Insulation Research begins a fundamental analysis of the breakdown phenomenon from the standpoint of observing the facts under the most simple circumstances. Sixty-cycle tests of porcelain insulators, to which the electrical engineer has devoted so much sweat and printer's ink, are not "simple." The heterogeneous composition of the porcelain — gas bubbles intermixed with crystal grains — and the continuous change of field strength in magnitude and direction shroud the facts producing destruction. "Electrocution in about 10^{-7} seconds by drilling of a hole through its body" (Fig. 1) is the clearest obituary notice such an insulator can expect.

By choosing direct-current voltage for the test, by using as object a transparent insulator of simple atomic design like rock salt, and by limiting the current flow during breakdown to low values, we can gain much more information. The drilling of the breakdown path can be observed "in action" (Fig. 2). It becomes evident that the path follows preferred crystallographic directions, and that the breakdown strength is a legitimate characteristic of structure and composition (Fig. 3).

Now the question "Who does the drilling?" has to be answered. The speed with which it happens would seem to indict electrons as the culprits guilty of the destruction. Hence we leave our solid insulator for a short intermission and try to learn what electrons can do in 10^{-7} seconds under high voltage and most simple circumstances.

The clearest conditions are found in gases. There are always electrons thrown out of atoms by radioactive radiation or cosmic rays, and as soon as voltage is applied they follow the field in a high-power dive. After speeding up sufficiently, the electrons throw secondary electrons out of the atoms in violent collisions, their

Figure 4. Discharge pattern developing around a positive electrode in 10^{-7} sec. (Nitrogen 370 mm., 5 KV)

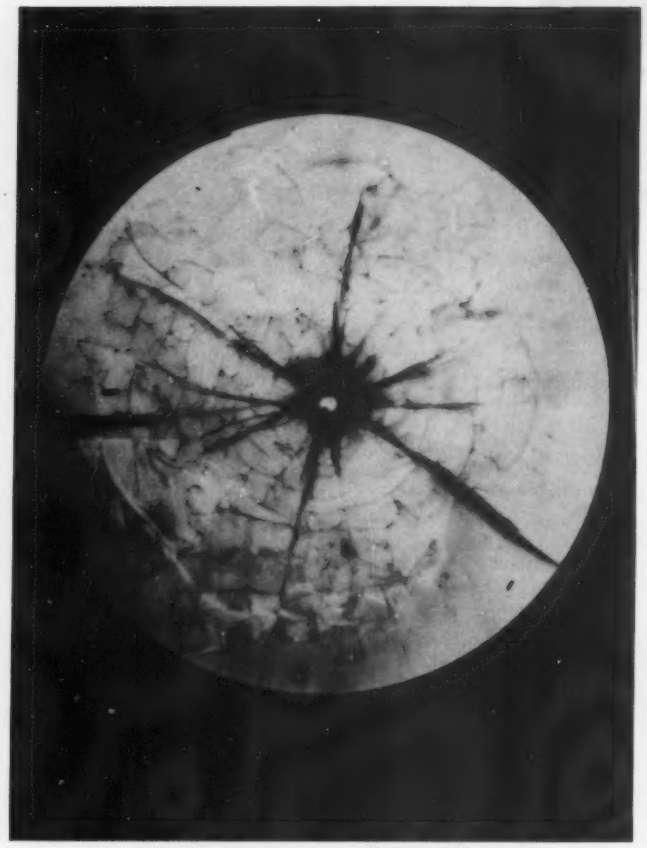


Figure 1. Glass plate, punctured and shattered by breakdown

number increases in avalanche fashion, and their path is strewn with positive ions which slowly drift to the opposite side.

We can photograph this breakdown of the gas insulation (Fig. 4) by the light emitted while electrons and atoms collide. The branches mark the positive ions and their distribution; each twig was formed by an electron avalanche. The field around the metal electrode in the center is completely distorted by the positive branches stretching into space and continuously lengthening under the effect of new avalanches streaming into their tips. If the field suffices, the distance to the counter electrode will be bridged over by a spark, a quasi-metallic mixture of electrons and ions concentrating the energy in the branch most favorably developed. Figure 5 shows different stages in the discharge pattern around a negative electrode — a thunderstorm landscape painted by electrons.

The analysis of such photographic records of gas breakdown gives detailed information about electrons under high field strength — information which can be applied to solids with great advantage. It points to electron avalanches as the responsible, hole-drillers of Figure 2 and raises a number of more pointed questions: How can electrons enter solid insulators? Do they move freely? Will they be trapped? How can they be released and accelerated?

To answer these questions, new experimental techniques have to be developed. The meager evidence to be gained by electrical measurements alone must be supported by information from other fields. In some crystalline insulators, electron clouds can be made visible and can be studied (*Continued on page 69*)

Figure 2. Breakdown path in development in rock salt

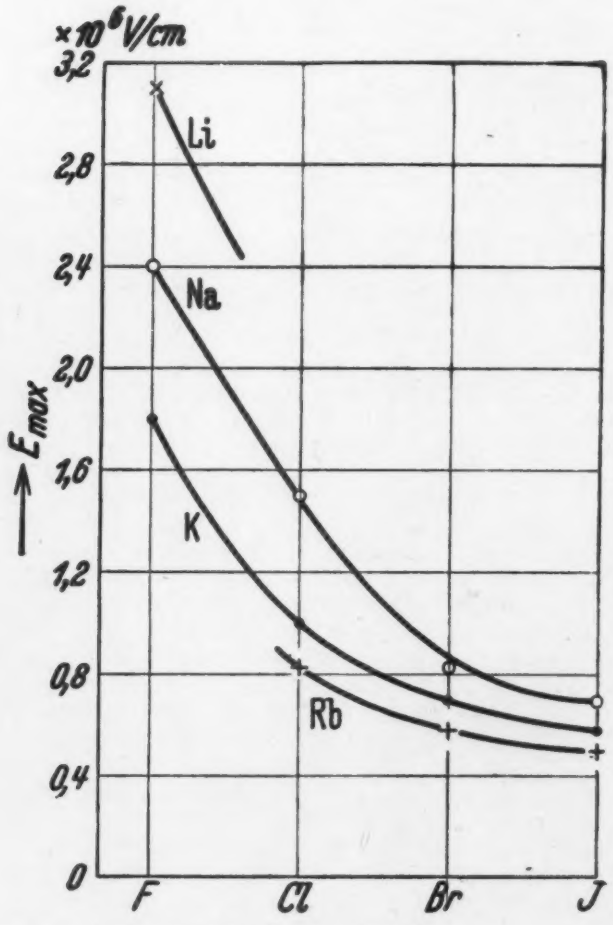


Figure 3. The breakdown strength of the alkali-halide crystals

MICROCHEMISTRY

THE MODERN METHOD OF ANALYSIS

By ALBERT R. SHELBY '45

IT is a recognized fact that the chemical analyst occupies a unique position in industry today. He plays a part at some point in the development of every industrial process going on in the manufacturing world of today. In order to play this part to the highest possible degree of efficiency the chemical analyst must combine in himself a widespread knowledge of the backgrounds of many fields with a very high degree of specialization in his own field. His is the function of a general chemical consultant able to discuss problems intelligibly with experts and to interpret analytical data in an intelligible manner to individuals requesting analysis.

The purpose of the chemical analyst is to provide in a minimum of time a picture of the composition and structure of a compound sufficiently complete to solve the problem at hand. Often this is not as elementary as it may seem. Ordinary laboratory analysis is not especially difficult, but at times it may be impractical to use this method. In some cases ordinary laboratory analysis would destroy a sufficiently large amount of a valuable material to make the cost of analysis prohibitive. Again it may be of vital necessity to know the composition of an extremely minute sample which may be all that is available. Sometimes the speed of ordinary laboratory analysis is prohibitive due to the slow rate of reactions. The increased rate of analytical reaction due to a decreased amount of reactants and increased surface would give the desired information in a third to a tenth the time taken by ordinary laboratory analysis. It can readily be seen that a different technique of analysis would be necessary to take care of these conditions satisfactorily. The solution lies in the micromethods of analysis.

The first man to attempt to solve this problem of handling micro amounts of material quantitatively in an analysis was Friedrich Emich of the Technische Hochschule in Gray, Austria. He published a book on this subject in 1909 — *Lehrbuch der Michrochemie* — which is still the basic text in qualitative microanalysis. In it he suggested the use of very diminutive apparatus to be used in connection with correspondingly infinitesimal amount of material. The radically different technique was termed microtechnique, but further research along these lines has developed a finer technique which is the true micromethod.

Emich's treatise and success with this newly developed branch of chemical analysis influenced Fritz Pregl who was at the Technische Hochschule in Gray at the same time. Out of necessity Pregl was forced to adopt microanalytic methods to solve a problem of composition of a small amount of organic material and with continued use he developed this new method to a very high degree. In 1913 Pregl had so perfected his new technique that almost all of the common quantitative organic analyses could be performed using only a few milligrains of material. Pregl was awarded the Nobel Prize in Chemistry in 1923 in recognition of his noteworthy achievement. The credit for early developments in microtechnique should be divided among several men, but it was not until after Pregl's work that microchemistry grew with remarkable rapidity.

The term "microanalysis" is practically self-explanatory although it is frequently misused to term techniques either finer or cruder than the true microtechnique. Actually microanalysis usually deals with analyses of materials weighing from one to ten milligrams. However, it is often necessary to use amounts of material weighing less than a gamma. (One gamma equals 0.001 mg.) In terms of everyday objects, a drop of water weighs about 50,000 gamma. A piece of copper wire one mil in diameter and seven mils long weighs one gamma. It is obvious that this is an extremely fine analytical technique.

Reasons for the use of such delicate methods are obvious. Often only a limited amount of a material can be made available for analysis. Such is the case when only small amounts of material are formed under conditions which cannot be duplicated due to a lack of knowledge concerning them. A spot of dust of unknown origin, a speck of corrosion product, or a localized sample taken from a point of a break are examples of limited amounts of materials which are often encountered in microanalysis.

The factor of economy of materials is a distinct advantage of the microtechnique. The ability of micromethods to give correct analytical data on a milligram of material has been a distinct advantage to research chemists working with rare and expensive vitamins, hormones, enzymes, etc. isolated by difficult and tedious processes. The composition of the female sex hormones isolated by Dr. Doisy would have been impossible to determine if microtechnique had not been made available. Such material, if assumed to be worth $5,000 per gram, would be worth $1,000 per 0.2 gram available sample. A single laboratory analysis would completely destroy this and leave nothing for any further analysis. A microanalysis would use $10 worth and leave 99 per cent of the compound for further experimentation.

Sometimes it is necessary to determine the constituents of a compound without removing or destroying an appreciable part of it. Microtechniques have been developed which leave a sample not only undestroyed, but practically untouched after a chemical determination has been made.

An appreciable saving of time can be effected by the use of micromethods. In almost all analyses the reare

operations whose speed depends to a great extent on the amount of material being used. Such operations are heating, cooling, filtration, evaporation, drying and many inorganic and organic reactions. Generally microanalysis is two to ten times more rapid than laboratory analysis, due to this increased rate caused by the decreased amount of reactants.

The small types of apparatus used permits the free use of gold, silver, or platinum in their construction wherever they are at all necessary. Expensive reagents can be used freely in view of the small amounts used. Due to the very small amounts of reactants, analysis of extremely explosive compounds can be safely carried out using the microtechnique. Large scale laboratory analysis of such materials might prove dangerous. It is readily seen that the advantages of microanalysis are many.

The small amounts of materials necessitated the development of radically new types of apparatus to handle these infinitesimal amounts. At first the microanalyst's apparatus was merely miniature reproductions of the laboratory types. However, new developments required the construction of radically different and unique pieces of apparatus. We may consider a container for a liquid as an example of the change in apparatus. Beakers and flasks of 100 to 1,000 cc. capacity are used in the ordinary chemical laboratory. Miniature reproductions of these containers of from 0.5 to 2 cc. capacity are used at the upper limit of the "micro" range. As smaller and smaller volumes are handled, capillary tubes and drops on glass are used until finally it becomes necessary to carry out the reactions in paper and textile fibers due to the extremely small amounts of reactants.

The quantitative aspects of microchemistry required the construction of a balance which would combine high sensitivity with a fairly high capacity. High sensitivity is not difficult to obtain with a small load, but the microanalyst often needs accurate weighings of comparatively heavy loads. Dr. W. H. F. Ruhlmann of Hamburg, Germany was the main contributor to the development of this balance. In 1911 he constructed a balance with a capacity of 20 grams and which weighed accurately to within one gamma at the maximum load. These balances must be protected from sudden temperature changes and mechanical vibrations, however. Even the hands of the operator must be brought up from both sides simultaneously after placing weights on the pan for the asymmetrical heating caused by the radiation from one hand alone will appreciably alter the zero point of the balance.

The micromanipulator is an excellent aid to the microanalyst. It is a mechanical device which makes such fine and precise movements that the dissection of single biological cells is possible. Specks too small to be seen with the naked eye have been satisfactorily analyzed with the help of this instrument. Also in the microanalyst's collection of apparatus are microscopes, small dentist drills, reagent blocks, centrifuges, colloidal milk, and many small accessories.

To obtain a truly representative sample of material for microchemical analysis is often very difficult. Homogeneous substances, of course, offer no problem at all, but not all substances encountered in microanalysis are homogeneous. However, if the compound can be made homogeneous by fusion or by being pulverized, there will be no difficulty in procuring a truly representative sample weighing a few milligrams. For instance, if it is possible to obtain a 10-gram representative sample for ordinary laboratory analysis from 100 kilograms of material, it should be possible to get a truly representative sample weighing one milligram for microanalysis from the 10-gram sample after it has been homogenized.

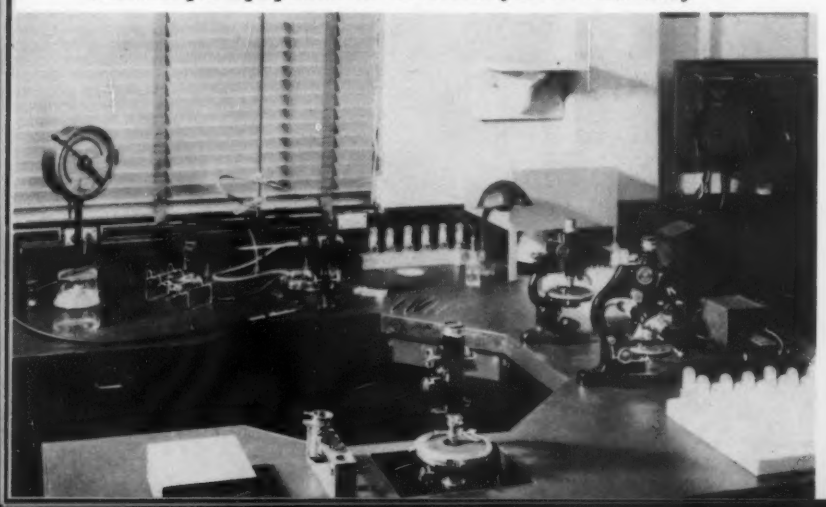
The number of methods at the disposal of the microanalyst are rather numerous. However, the so-called "spot test method" is the most widely used qualitative test in microanalysis. It was developed by Professor Fritz Feigl at the University of Vienna and he published a book on it in 1930 after twelve years of research.

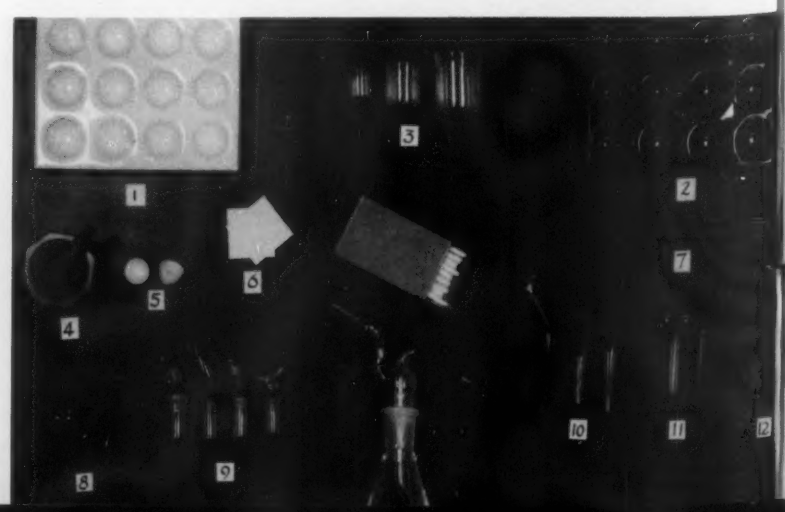
The procedure of a spot test consists of placing a small amount of the solution to be tested on specially impregnated filter paper and observing the character of color of the spot formed. From the observed result, conclusions can be drawn as to the nature of the unknown. The litmus paper test is a spot test familiar to most people which identifies the hydrogen or hydroxyl ion.

The spot test method will identify minute amounts of compounds very accurately and very quickly. This speed and accuracy in qualitative determination saves much of the analyst's time if the sample must be analyzed quantitatively. The analyst can then know what ions and groups must be quantitatively determined and what complicating ions or groups exist in the sample. Complicating ions or groups are not a very serious problem in spot test analyses due to the varying rates of diffusion of colors and precipitates through the spot paper and the numerous alternate tests available. Spot tests are sensitive in some cases down to .03 gamma per .05 cc. drop. This sensitivity is sometimes a disadvantage for it will identify an ion which is not present in sufficient amounts to be quantitatively determined. Dilution tests must be used to show the concentration of a qualitatively identified ion to be significant. The so-called "C. P." reagents are very contaminated for spot testing and microchemistry in general due to this sensitivity. Spot test reagents must be specially prepared and stored to insure absolute purity.

Polarized light and the spectroscope are devices invaluable to the microanalyst. Identification of crystals is possible with the former. Electrographic determination of metals using impregnated paper as the vehicle for ion transfer is a method (*Continued on page 66*)

Microscopic equipment in Microanalytical Laboratory





IBM INTERPRETING REPRODUCER

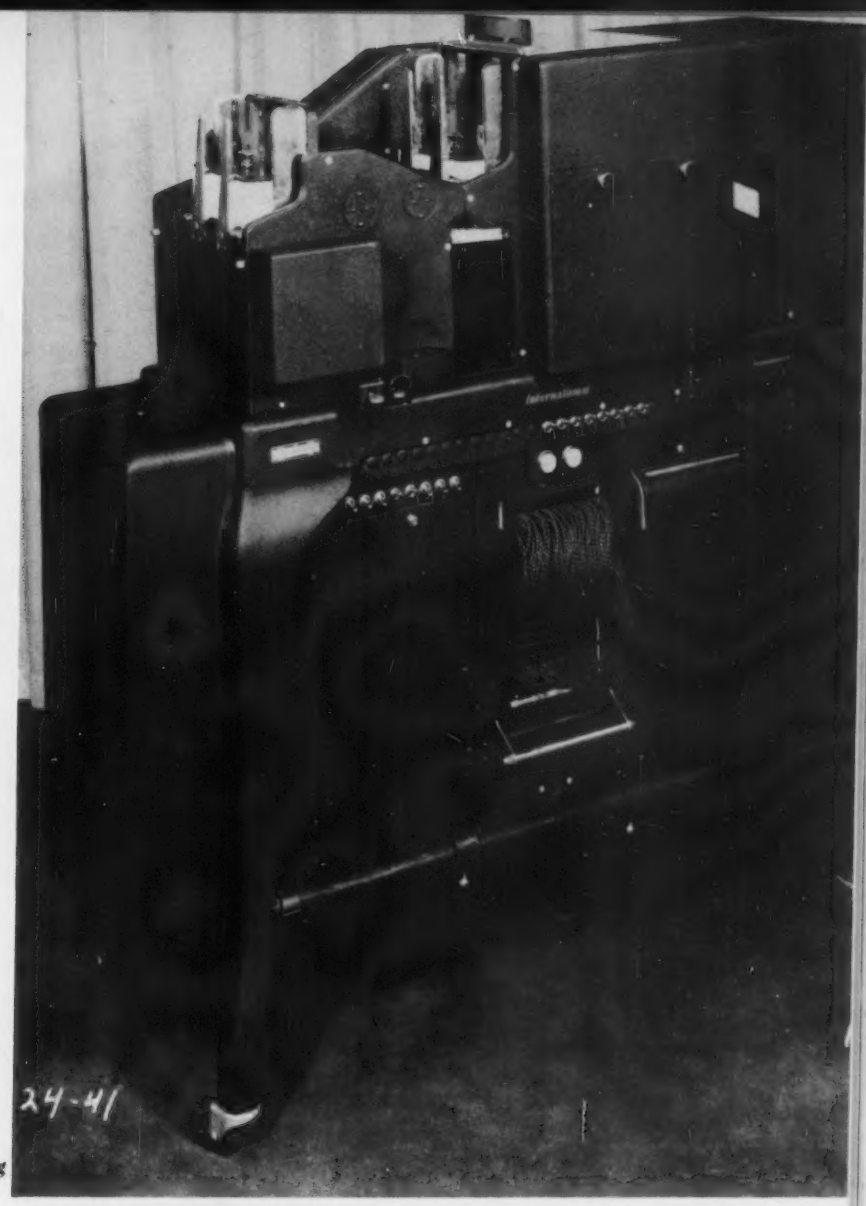


Figure 1. The Interpreting Reproducer provides a connecting link between work time recording and payroll accounting

AS the needs for speedy, economical and accurate organization of business facts have grown during the past few years, increased by war demands, the science of recording, tabulating, and accounting has kept pace. An example of this has been the design by International Business Machines Corporation of an Interpreting Reproducer (Fig. 1) to accelerate payroll recording and accounting, and at the same time to reduce the human element of error.

This machine automatically prepares daily attendance card records which are used by each employee to register the time when he arrives at and leaves the plant. These card records serve as the basis for automatic preparation of the complete payroll. Each card bears in punched hole form (Fig. 2) information relative to the individual employee. Thus, employee number, department, rate per hour, etc. are included in the card. Each card has the employee number printed in large figures across one end. The cards are placed each day in racks, and, because of the large printed employee number, each man can readily locate his card so that he can insert it in the attendance recorder to register the hours which he works.

Before the advent of the Interpreting Reproducer, two separate operations were required to obtain this daily attendance card:

1. The reproducing of the punched hole information from a set of master cards to the daily card.
2. Printing the man number on the cards.

The first step was performed by the International Reproducing Punch, and the second step by either the Printing Interpreter or by some form of conventional printing.

There were several objections to this:

1. Too much time was required to complete the job.
2. The man number was printed on top of the card rather than on the end, and was printed in figures which were too small to be readily discernible.
3. Conventional printing left too much leeway for the element of human error.

The Engineering Department made a preliminary study of the problem and finally recommended the design of a new machine — the Interpreting Reproducer — which would comprise the features of the Reproducing Punch and the Printing Interpreter. The decision to build this type of machine was reached after considering the following advantages:

1. The combination machine would eliminate the necessity for handling cards twice and also for performing two independent operations.
2. Design for card feed, sensing brushes, and punching mechanism had been perfected, tool equipment for all this mechanism was available, and the existing mechanism might be employed to advantage in the machine.
3. Production costs would be reduced for a combination machine as compared with building two machines.

The Reproducer Punch is comprised of two physi-

cally separated, but mechanically and electrically interrelated units: a master card reading unit and a detail card punching unit. The reading unit is designed for sensing the perforations in cards as they pass the sensing brushes. Electrically timed impulses sensed by these brushes were already used to control the punching, and an additional set of brushes in this unit was used to prove the punching of each new card. It was decided to employ this same set of brushes to control the printing on the new card so that all important new designs might be confined to the printing and punching unit.

Figure 3 is a sectional drawing which shows the mechanism employed in the punching unit before incorporating the printing mechanism in the design. Figure 5 is a schematic drawing showing both units of the mechanism in the Interpreting Reproducer, which displays the relative position of the cards in these units during the successive machine cycles.

In reference to Figure 4, it will be noted that numbers with the master card drawing, 1, 2, 3, and 4, refer to positions in the successive movement of the card through the mechanism and that on the same Figure 4 with the comparing and punching units are corresponding numbers, showing positions of the detail card with relation to master card position. For example, position 1 of the master card corresponds to detail card position 1. It is interesting to observe from this drawing that each detail card passes through two more operations than its master card, viz., position 5, at which the number printing occurs, and position 6, at which the stacking is accomplished. Figure 5 is a timing chart showing details of steps 2, 3, and 4 of Figure 4.

The general timing of the machine might have been considerably simplified if it had been possible to punch and print at the same location in the machine, but since this would have limited the space required for punching on the card, it was decided to design an interpreting mechanism to occupy the space originally required for the card stacker. It was also decided to carry each card beyond the printing location by auxiliary feed rolls to a new stacker located at the extreme right end of the machine. This change made it necessary to lengthen the machine approximately six inches and to rearrange the mounting for the drive motor.

The most important problem in the design of almost any punched card controlled accounting machine is timing, particularly in electrically controlled machines where the controlling record is sensed in motion, or where the card must stop and start a great many times during the course of a single machine cycle. The punching unit of the Reproducer is coördinated with the feed roll driving mechanism to permit starting and stopping the card at each horizontal row of perforations. The feeding rolls are driven by a geneva mechanism, utilized to drive the card step-by-step with a minimum of shock. The card remains motionless during about 225 degrees of each revolution of the machine, and the punching and punch selecting mechanism is arranged to operate during this time interval to punch those perforations across one horizontal line of the card.

This arrangement makes it possible to employ the same punching mechanism for successive rows of holes. The motion of the card through the punching mechanism might be compared to the passage of the fabric under the needle of a sewing machine.

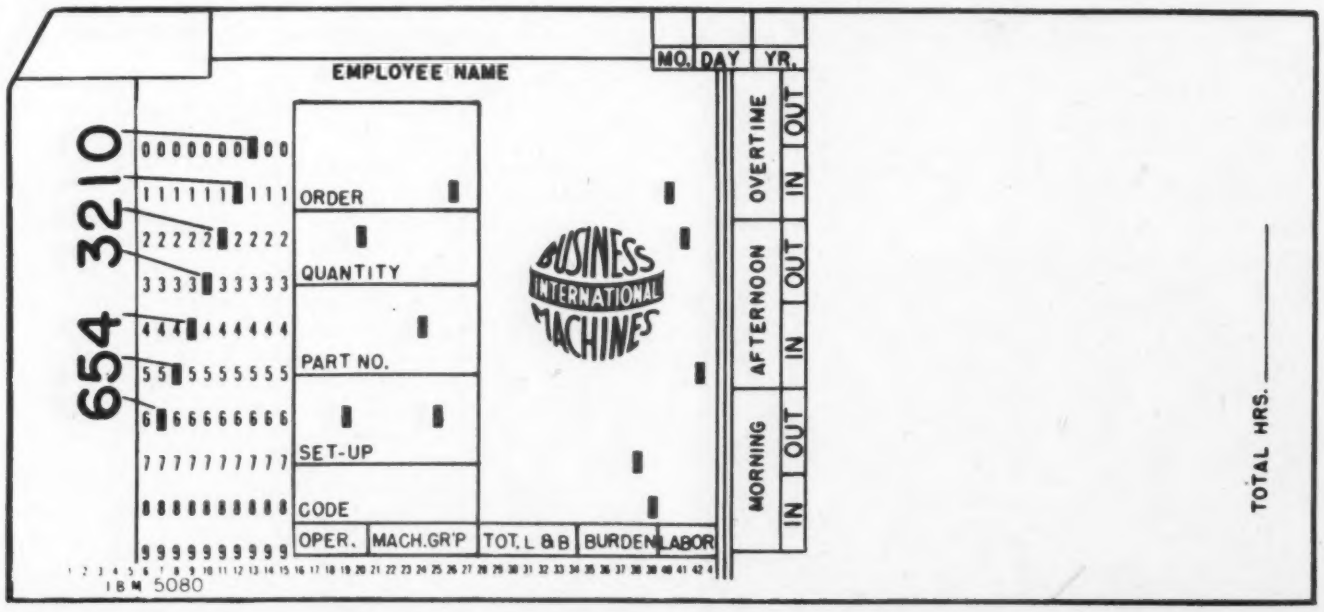
The geneva mechanism in the Reproducer is arranged to rotate 14 times for each machine cycle and accordingly the cards are spaced one-fourth inch apart and each card moves 14 times during a machine cycle. Hence if the geneva mechanism is driven 1400 RPM the machine will punch 100 cards a minute. It was considered undesirable to reduce the high rate of speed of the punching, and, therefore, it became necessary to adapt the speed of the interpreting device to the card feed arrangement and drive already employed for punching.

Three pairs of feeding rolls in the punching unit are driven intermittently. When the machine is operating at normal speed, these rolls start and stop 1400 times per minute, the gearing and roll size being calculated to produce a one-fourth inch movement at the periphery of the roll for each step of the operation. The time interval when the card is at rest in any position is only .024 second. The printing of numbers on the card must be accomplished during this interval of time.

It was decided to utilize type wheels and an ink ribbon for this printing operation. However, due to the speed at which printing was to be effected, it became apparent that conventional means, such as moving the type wheels against the card and backing up the card with a platen, could not be employed.

As a result of experiments with high speed crank-operated mechanisms it was decided to employ this drive principle for printing and to devise means for selecting and positioning type wheels according to a basic cycle having a greater number of divisions than

Figure 2. The electric accounting machine card, showing holes punched at various points



the 14 "point," or 14 space, cycle employed for punching in the Reproducer.

A high speed oscillating bail is employed as an actuator for the punches in this machine, shown in cross-section in Figure 3. The bail is driven by connecting rods from the eccentric shaft shown at the top of the drawing. The bail oscillates 1400 times per minute, there being one stroke of this bail for each horizontal row of holes which are to be punched on the card. Selected punches are mechanically associated with the oscillating bail during the down strokes of the bail. This selection is under control of a group of interposer magnets, there being one magnet for each punch.

Energization of the magnet causes an interposer, which is pivoted at the upper end of the punch, to be rocked toward the right so that a notch of this interposer will be engaged with the bail. As the bail continues its downward stroke the punch will be driven through the card and will be positively returned. The harmonic motion of the crank-driven bail is transmitted to the punch throughout a major portion of the bail stroke.

The mechanism in the Reproducer has proved very satisfactory in use, and hence it was decided to employ the same general type of driving means for a platen which would be mounted above the card line. An electrically controlled type wheel unit was designed and mounted in such a position that the surface of the selected type would be on a horizontal plane slightly below the lower surface of the card. The type wheel unit is a complete machine in itself, comprising type wheel driving cams, individual wheel driving means, controlling magnets, stop pawls, ribbon feeding and reversing mechanism, etc.

The high speed platen was arranged to be driven from the crankshaft, which was extended through the front frame of the machine and was provided with an additional eccentric member, a connecting rod, a universal joint, and suitable linkage to oscillate a platen operating bail. This is located at right angles to the punch operating bail and in a position at the right of the third pair of feed rolls, which was the position selected to effect printing. This bail operates in synchronism with the punch operating bail, and is arranged to be utilized as a driving means for the platen whenever the latter is coupled to this bail upon energization of the platen operating magnet.

The platen operating mechanism (Fig. 7) shows important parts of this mechanism. Two magnets and two interposer pawls are employed, one at either end of the platen in order to lighten the operating parts insofar as possible and to provide a simple means of equalizing the load on the driving arms at either end of the platen bail. The magnet is energized momentarily in order to couple the platen to the operating bail for one stroke of the latter per card cycle; in other words, the bail is arranged to idle 13 times and to be coupled to the platen for one active driving operation in each series of 14 punching cycles (see timing chart, Fig. 5). The platen is forced down against the back of the card which, in turn, is pressed against the face of the type wheels.

A wide, heavily inked silk ribbon is held in position across the face of the type bars, and a clear impression is transferred from the type wheels to the face of the tabulating card. As the platen operating bail is raised, the platen bail is uncoupled from the operating bail and the platen remains in its normal position until the next card is in position for printing. Figure 6 shows the design of the ribbon feed and reverse mechanism.

The preceding paragraphs have dealt with the mechanism which was designed (*Continued on page 64*)

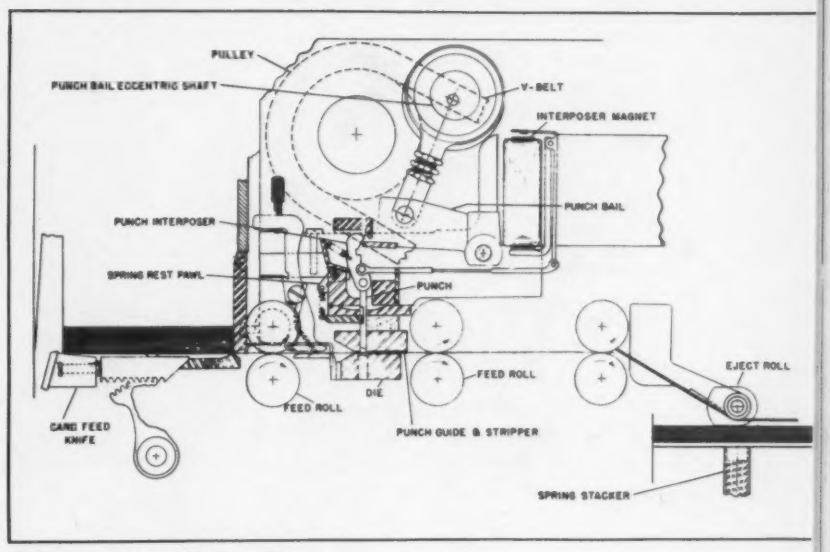


Figure 3. Punching unit

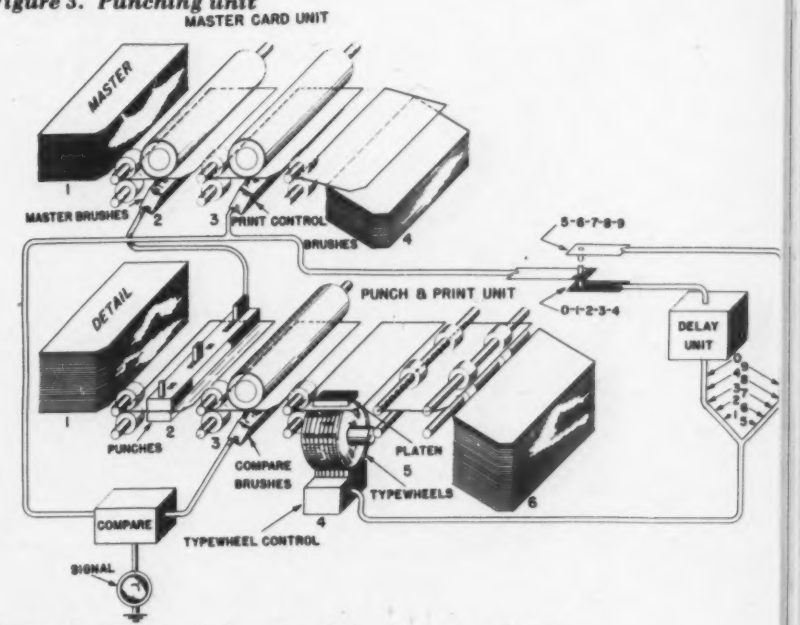


Figure 4. Schematic drawing of the master card unit

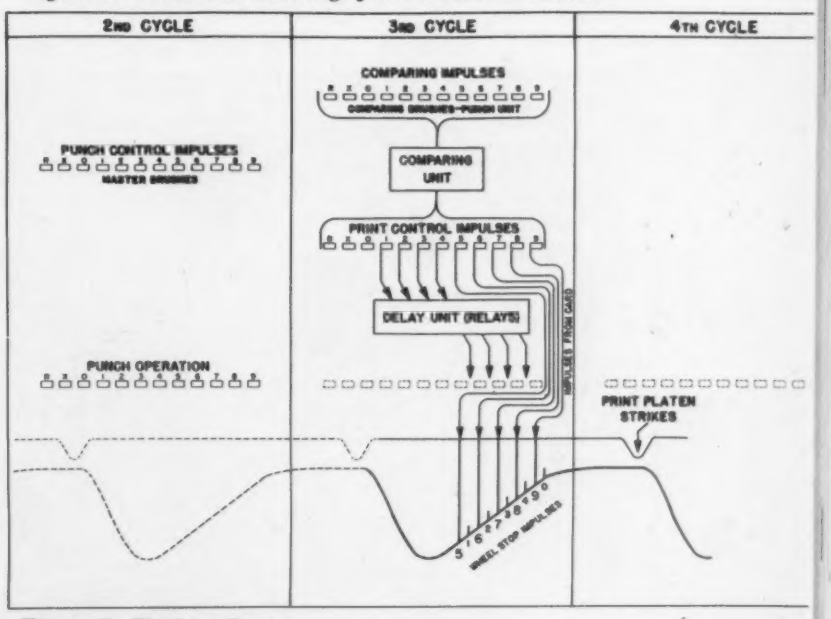
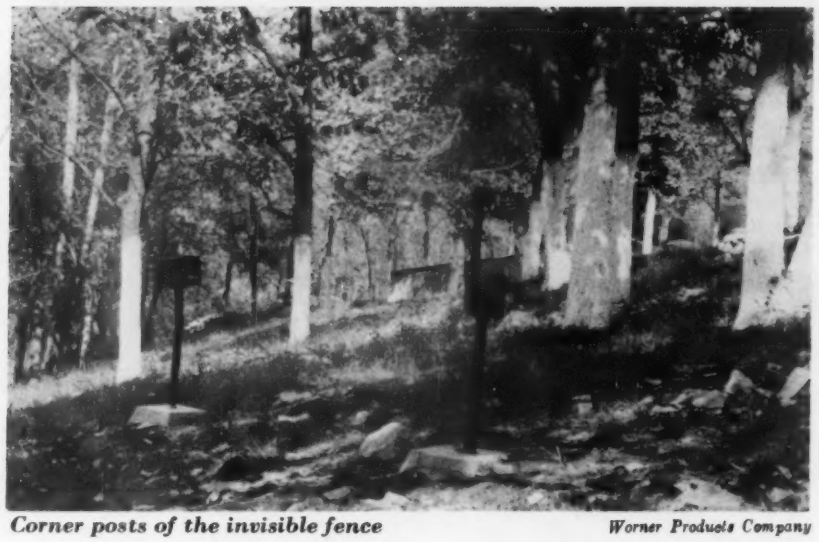


Figure 5. Timing chart

INVISIBLE POLICEMAN



Corner posts of the invisible fence — *Worner Products Company*

LESS THAN 7200 ANGSTROMS STOPS SABOTAGE

By ROBERT E. APPEL
WORNER PRODUCTS COMPANY

America's first line of defense is production, yet all too often this vital production is halted by sabotage. Two engineering developments, whose effective use foils the saboteur, are protective lighting and photoelectric cells, the first of which was described in the last issue.

SUDDEN, urgent, national need has given great impetus to the development of one of radio's near-relatives — Photoelectric Equipment. The relationship is based on the fact that its "main organ," the photocell, is similar in many respects to a radio tube. Its function, however, is different from that of radio since it is employed to "observe by electricity," and that is how it got its common name, "electric eye." Actually it does more than merely observe — it also controls electrical apparatus.

First electricity was developed and harnessed to do man's routine *work;* then came Photoelectric Equipment to do man's observing and routine *thinking* in the control and operation of all manner of electrical servants.

When the Pearl Harbor treachery changed defense to all-out war, Photoelectric Equipment was given the job of guard duty against sabotage. "Remember Pearl Harbor" has an additional meaning beside the call to vengeance. It has an industrial interpretation which says to every factory owner — "Remember how the Japanese stabbed us in the back at Pearl Harbor while diplomats were shaking hands in Washington. Don't let an industrial Pearl Harbor take place in your plant."

Never before was the successful outcome of war so dependent on industrial production, and never before were the producers of war material so dependent on other manufacturers. Every factory and parts manufacturer is part of a chain supplying the materials needed for Victory. The manufacturer who dismisses the idea of anti-sabotage protection for his own plant with the notion that it is only for the industries shipping directly to the war fronts, is making a grave mistake. A saboteur can cripple production of a war commodity just as effectively by injuring some factory producing parts as he can by attacking a big war industry. Manufacturers of munitions depend on dozens of sources for chemicals, paper, metal, and machinery. Manufacturers of such equipment as tanks, trucks, and ships do not make every nut, bolt, wire, flange and lens that they use. There are opportunities for sabotage among all their suppliers.

The need for anti-sabotage protection is not confined merely to manufacturers; it is needed also by water works, gas works, electric power companies, coal mines, coal yards, docks, shipyards, airports, oil companies, refineries, oil and gasoline storage plants, gas pipe-line companies, railroads, telephone and telegraph companies and many other concerns that are in the operating rather than the manufacturing business.

Readers who are not familiar with Photoelectric Equipment will, at this point, want a brief explanation of the principles involved. A unit called a Light Source throws a beam of light into another unit called a Receiver. In the receiver the beam strikes a photocell. As long as the light continues to strike its current will flow in the photocell circuit. Any interruption in the light beam will instantly stop the flow of current in the photocell circuit. This action in turn operates a relay which controls any electrical device to which it may be attached.

In this will be seen the basis for design of Photoelectric Anti-Sabotage Equipment. Worner Products Corporation has developed the light source into a long range light projector, the beam of which remains concentrated for a distance of over 500 feet. To provide the necessary secrecy, the light source is provided with a light filter on a slide. This filter cuts off the light at 7200 angstroms so that it projects only invisible (infra-red) light.

The receiver has become highly developed optically as well as electrically. It is made to exclude, as far as possible, all light except that projected by the light source. Only the light properly "aimed" from the light source will be admitted to strike the photocell. This prevents the saboteur from using a flashlight to energize the photocell while he steps through the beam. He would not be able to "aim" the flashlight into the receiver without getting his hand in the beam, which would of course set off the alarm. Electrically the receiver has been developed to such sensitivity that it will operate on invisible light rays at 500 feet from the light source.

Since many of the anti-sabotage installations are out-of-doors there have been developed special outdoor housings for these units. These weatherproof cases are provided with visors over the projector of the light source and the beam-hole of the receiver. Bottoms of the cases have flanges threaded to receive 1½ inch pipe. At the point of installation supporting posts are made by imbedding 1½ inch pipe in blocks of concrete. Units are so devised that when installed in this manner vibration caused by passing traffic will not shake the beam off its "aim" and cause a false alarm.

Some general information about layout of invisible fence can be gained from the diagram of the invisible fence corner. The two units shown at the corner may be both light sources, both receivers, or one of each, since they are not aimed at each other anyway. Each one is "aimed" at its mate which forms the next post of the invisible fence. Actually the corner of the invisible fence is not at any post but at point where the two beams cross (indicated on drawing by letter *C*).

An invisible fence may be connected to a centrally located signal system so that signal lights will locate the trespasser within 500 feet of the point of trespass. Audible alarms may or may not be connected depending on whether or not it is desirable to let the trespasser know he has been detected.

An interesting point in this connection contrasts World War No. 1 with World War No. 2. In the first world war vital industrial properties were protected against sabotage by keeping them constantly illuminated with floodlighting. During this war, continuous floodlighting instead of being a protection would be a menace to safety. In its place "surprise floodlighting" is used. This consists of an invisible fence connected to turn on floodlights when anyone goes through it. The surprise floodlights put the trespasser "on the spot" and make him a target for armed guards should he try to escape. Modern military tactics have brought about the blackout which provides further uses for installations of Photoelectric Equipment. During a blackout the street lights go out but no other electric power is shut off at the main plant. Illuminated billboards and electric signs cannot be covered up and it is impractical to have someone constantly on watch beside the switch of each billboard and electric sign. This problem is solved by Photoelectric Equipment. A nearby street light is used as a light source. The receiver is connected to turn off the billboard or sign when the street lights go off and turn them on again when the blackout is over.

Photoelectric anti-sabotage and anti-espionage equipment is also made for indoor installations. Such equipment is known as a Trespass Trap. Trespass traps for anti-espionage are the same as for anti-sabotage, the difference being only in the application. A trespasser may have no intention of destroying anything. He may only want to make observations, drawings or photographs. That is why trespass traps are set to guard drafting rooms, laboratories, document libraries, etc. Where a number of trespass traps are installed in the same building a central signal system may be connected to indicate the exact room in which trespass is taking place.

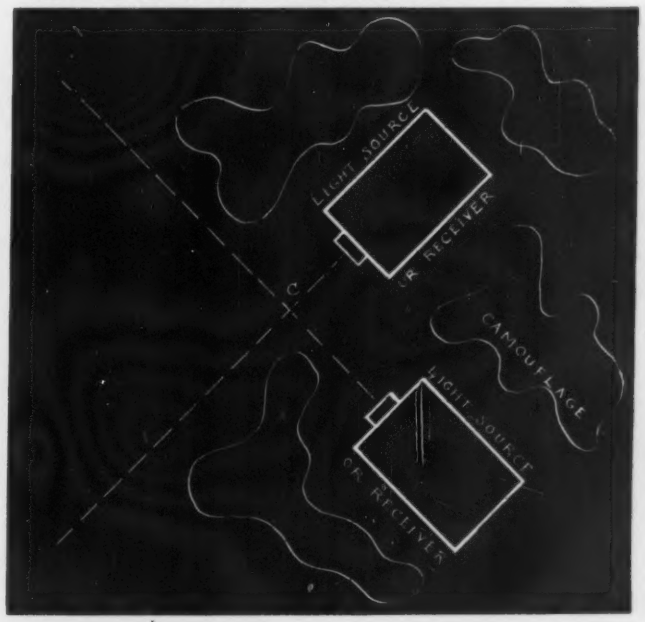
Quite often indoor areas are protected by what is known as a closed circuit alarm system. This consists of a fragile foil tape which is placed around the perimeter of all panes of glass. All door jambs have contacts to complete the circuit. This circuit is connected to an alarm system in such a way that when the circuit is broken by forcing a door or breaking a window an alarm will operate.

Two limitations of the closed circuit foil system are apparent. One is that its presence is not secret. Anyone planning to break in can tell by looking at the windows that the foil system is installed. Another limitation of the closed circuit system is that it does not protect against trespass by concealment. Suppose, for example, an espionage agent wants to inspect or steal some blueprints from the drafting room of a machine gun factory. Most likely the espionage agent is not going to attempt to break into the building and then into the drafting room. A more likely way would be for him to become an employee and eventually arrange to conceal himself in the drafting room. After accomplishing his purpose he is ready to leave. He decides which window or door he is going to leave by and then attaches a piece of wire to the foil circuit on both sides of the point where he intends to break out. This being accomplished, the wire will form a shunt, even when he breaks the original closed circuit.

Such circumvention cannot be made when trespass traps are used. With them it is a matter of indifference whether the trespasser breaks in through a door, window, ceiling, floor or wall. In fact, even if he gains access by concealment the result is the same. As soon as he starts moving around he intercepts a beam of invisible light which sets off the alarm. Alarm can be given locally or connected with the office of some law-enforcement agency, or both.

In making indoor installations it is not necessary to have a separate trespass trap for each beam of invisible light. One beam can be reflected from a number of focusing mirrors before being finally reflected into the beam-hole of the receiver. This makes a virtual web of beams in the room and intercepting any reflected beam has the same effect as breaking a direct beam.

Units at a corner of an "invisible fence"



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FRANKLY SPEAKING . .

SALVAGE FOR VICTORY

Prior to the entrance of America into the war, the Defense program and Lend-Lease aid to Britain, Russia, and China had reached such proportions that it had become necessary to begin a national salvage campaign that would reach into every home as well as industry. The actual war, however, makes it necessary to use every pound of materials, including so-called waste materials, for war industries and the essential civilian economy. No American must fail to realize the extent of the curtailment of supplies essential to our war production.

There is, of course, no need for undue alarm. We have prepared somewhat for the condition that now confronts us. Stock piles have been accumulated; new sources of critical materials are being tapped; substitutes have been and will continue to be found and used; every possible economy in the use of the materials we already have will be achieved.

But the greatest source of many of the materials we must have are the waste piles scattered over the face of America. In homes, shops, and factories, on farms, in city dumps, in automobile "graveyards" there is a huge untapped mine of scrap metal, paper, rags, and rubber. Not one pound of this rich source of essential material must be left lying idle and unused. It is estimated that scrap obtained from the automobile graveyards alone would amount to 3,500,000 tons. Since new steel contains about 45 per cent scrap, the phenomenal rate at which the steel industry is now producing makes it obvious that every bit of scrap iron in the country is absolutely necessary to assure increased production.

The drive for waste materials has only begun. The salvage of materials critically needed to wage war on the Axis powers is an immediate and grave responsibility for everyone. It is up to the entire country to *save* for war production.

RECENT TRENDS

Increasing national concern over labor problems and labor relations controversies has been reflected at M.I.T. by growing interest of the student body in such matters. This intensified interest has been expressed tangibly by a very practical curiosity about unions, labor legislation, industrial labor relations, and the whole field of sociology.

This new attention to labor problems has not been overshadowed by the present war. In fact, the war has brought into sharper focus a realization that labor conflicts do exist, and that these conflicts are far too many and too bitterly contested to be indicative of a completely healthy state of affairs. They constitute a definite problem, not only for peacetime but even more for war, a problem to which we are properly devoting more and more time and thought.

At M.I.T. this interest has taken the form of increased study of the problem. The best indication of this is the rapid growth (*Continued on page 71*)

Lasher wins War on Weather!

For years, telephone cable has been hung by stiff wire rings from its supporting strand. But repeated expansion and contraction caused by temperature changes sometimes proved too much for even the best cable sheath. Fatigue cracks developed near the poles—this meant leaks—possible service interruptions—expensive repairs.

Recently, men of the Bell System developed a machine that lashes the cable and strand together in such a way that the concentration of strains near the poles is minimized. The Cable Lasher has also proved a great aid in the speedy installation of some of the new cables needed for airfields, camps, bases and war factories.

There are many opportunities in the Bell System for men with the urge—and the ability—to do a job better than it has ever been done before.

BELL SYSTEM
AMERICAN TELEPHONE & TELEGRAPH CO.
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IBM INTERPRETING REPRODUCER

(*Continued from page 59*)

to operate the printing platen at a suitable speed to endure initiating and completing the printing operation while the card remains stationary and in the grip of the third pair of feed rolls. Immediately after printing has been effected, these rolls resume their normal operation. The card is ejected from these rolls and into the grip of a pair of constantly turning rolls. These latter rolls rotate at a higher peripheral speed and carry the card away from the printing station through auxiliary rolls, depositing it in the stacker.

The type wheels in the interpreter unit are provided with engraved figures on one-half of the periphery of each wheel and with control teeth or notches correspondingly spaced on the other half of the periphery. These wheels are mounted on a self-lubricated sleeve assembly which is oscillated by a pair of cams, one active and one complementary, which are mounted on the camshaft of the interpreter unit. These cams oscillate a gear sector which meshes with a gear on the type wheel sleeve.

In an ordinary type of punched card printing machine, the type selecting drive would have been synchronized with the sensing of the controlling card; in other words, the type wheel drive would have been designed to rotate the type wheel one tooth space during the same time in the cycle when the controlling record card had been advanced one space; in other words, the type wheel would have been advanced from a normal position to a "nines" printing position during the time in the cycle when a "nines" row of perforations were sensed by the brushes, the type wheels would have been rotated an additional tooth space from nine to eight during the time in the cycle when the "8" row of holes was being sensed, etc.

Unfortunately, this timing relation could not be employed in the Interpreting Reproducer for two reasons:

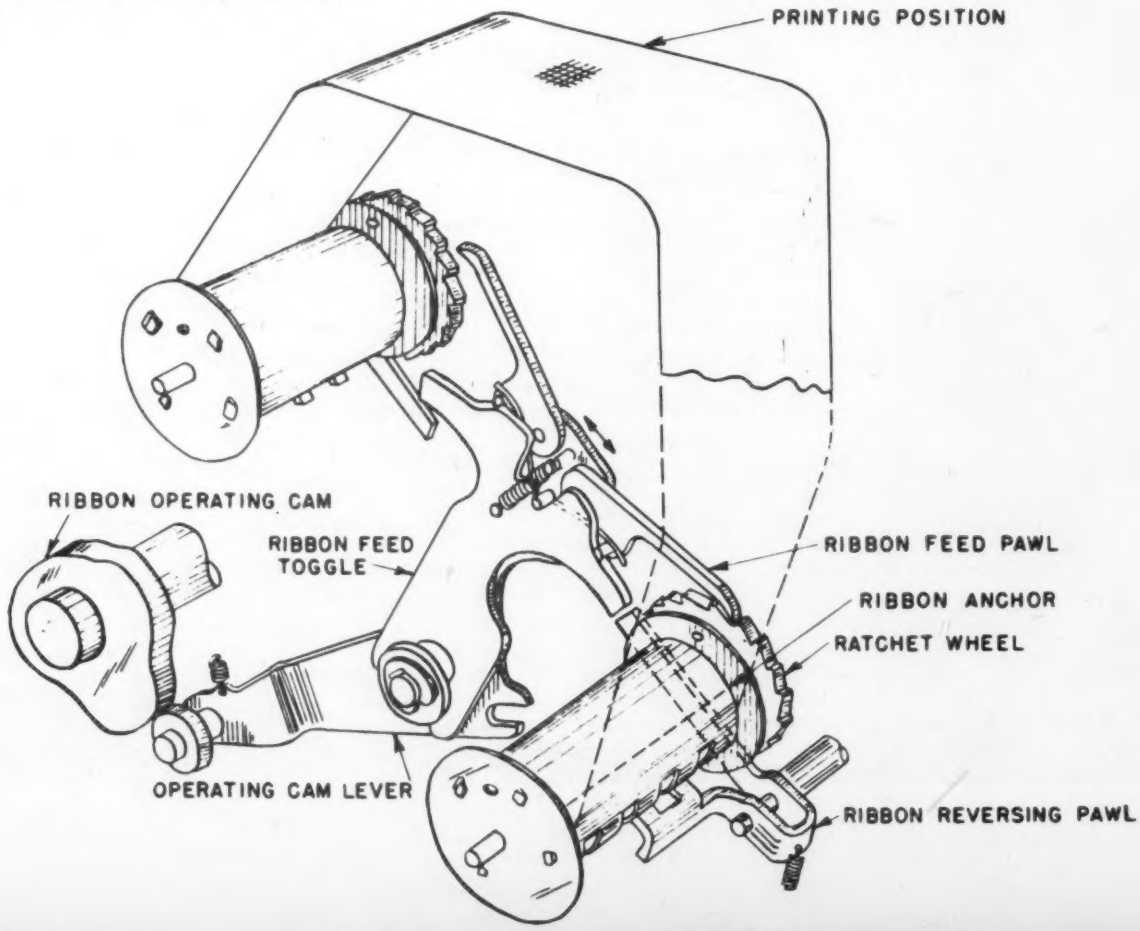
1. There would be no time interval for printing.
2. There might be too heavy a shock in restoring type wheels to 0.

The punching mechanism is designed to perform a complete punching operation at each of 12 positions on the card, and there will be two idle strokes of the punch bail between punching operations on successive cards. There are no heavy reciprocating parts in this machine which must be returned to a normal position between card cycles, and accordingly the relatively low 14-point cycle was employed in order to provide the maximum possible time for each individual punching operation.

Such a timing arrangement is not well adapted to sensing the various card perforations to control the positioning of type wheels. Assuming, for example, that 10 numerical positions were sensed and that the type wheels were rocked into position in synchronism with the passage through the sensing brushes of these 10 numerical perforations and that only one additional 1/14 of the machine cycle was employed to effect printing, it would be necessary to return the type wheels to a starting position in 3/14 of a cycle; i.e., the operation of returning the type wheels to normal position would have to be effected in approximately 3/10 of the time which had been utilized to set up these wheels at the selected positions.

This rapid restoration of type wheels would be undesirable as it would introduce a heavy cam load, shock and wear at one point in the cycle. The normal solution of such a problem would be to "expand the cycle," i.e., the cycle may be changed from a space of 14 divisions each 25 5/7 degrees of machine time, to a 20-point cycle, in which case each horizontal row of holes in the card would be sensed during 18 degrees of machine time. Such a solution would be impracticable as it would result in an overall reduction in the punching output of the machine. (*Continued on page 69*)

Figure 6. Ribbon operating mechanism



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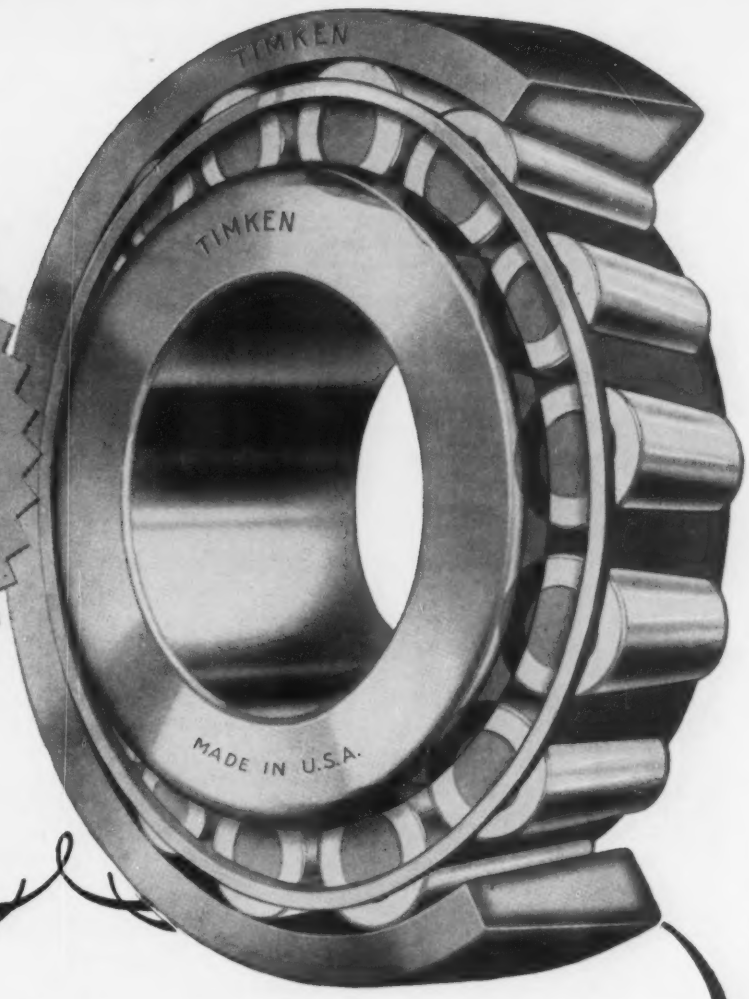

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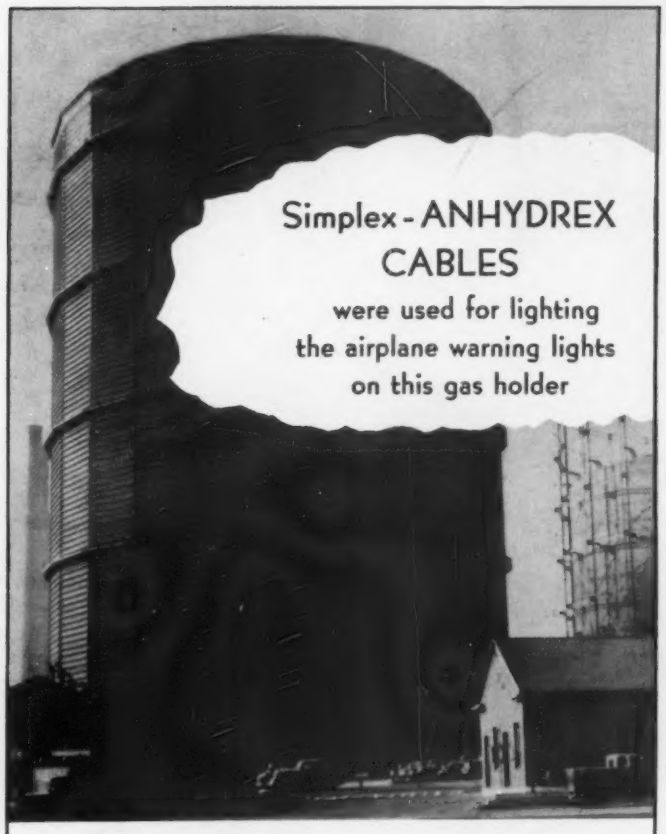

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MICROCHEMISTRY

(*Continued from page 56*)

used by the microanalyst. X-ray and electron diffraction structural analyses are often used by the microanalyst to supplement his work. Ultraviolet light is extremely useful in the identification of organic substances by fluorescence. Thus it can be seen that microanalysis is the combination of a wide range of methods into one technique in order to give a clear, accurate analysis of a compound and give it quickly and economically. Microchemistry cannot be considered the unfailing method of solution of any and all problems, but it is an extremely powerful method whose full potentialities have not been fully realized. Its possibilities are virtually unlimited.

CLASSIFICATION OF CHEMICAL METHODS

Methods	*Amount of Material Used*		
	Grams or Kilograms	*Milligrams*	*Gammas (γ = .001 mg.)*
Technical	Kilograms $.10^n$		
Semi-technical	Kilograms		
Ordinary laboratory	1 g. to 1 kg.		
Macro (decigram)	0.1 to 1.0 g	100 to 1000	
Semi-micro (centigram)	0.01 to 0.1 g	10 to 100	
Micro (milligram)	0.001 to 0.01 g	1 to 10	1000 to 10,000
Ultra-micro (gamma)	0.0001 to 0.001g	0.1 to 1.0	100 to 1000
		0.01 to 0.1	10 to 100
		0.001 to 0.01	1 to 10

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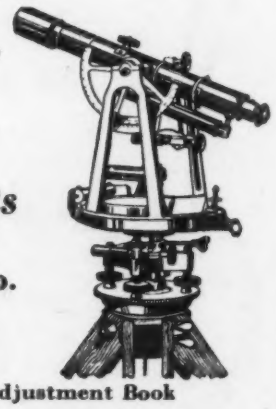

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How is America meeting this tremendous responsibility? You'll get a fair idea at such great factories as the Westinghouse plant where the machinery to drive many of those supply ships is being built, or at the huge Westinghouse-operated Maritime Commission plant which is now being erected alongside it.

The "know how" that works 24 hours a day

There, in these factories is a dramatic example of how Westinghouse "know how" is doing a job for National Defense.

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A salute to the "Class of '41"

In the all-out Westinghouse war effort, no group in our entire organization is more deeply engaged today than the 600 young engineers who last year left your campus paths to join this company. In research, design, production—they have already made important contributions.

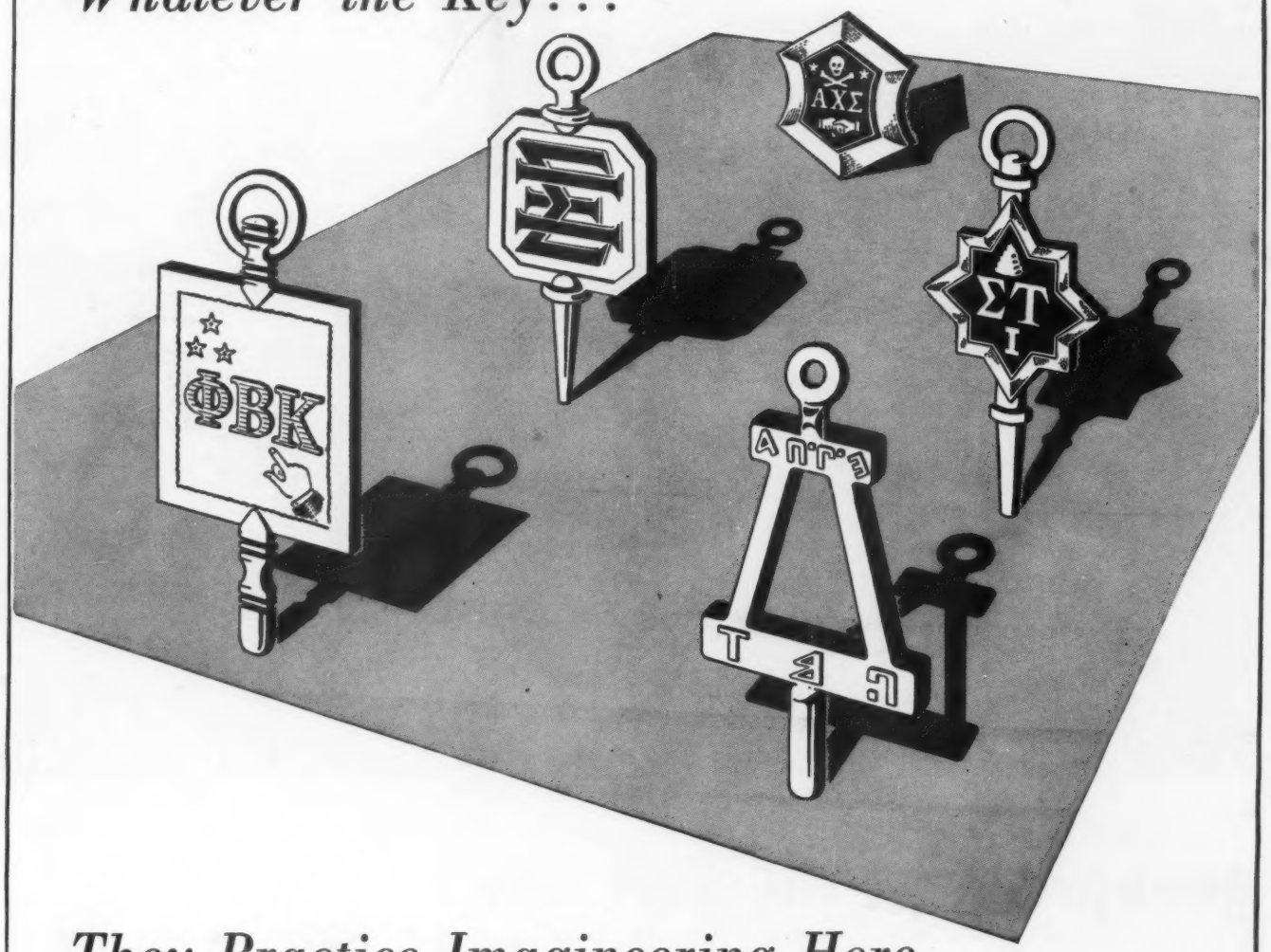
This year many more engineers will come to us from your college and others to mesh their eager talent with our "know-how" and apply it to their country's defense. Certainly nowhere does there exist a greater opportunity for them to translate their intelligence, skill and enterprise into vital service. For Westinghouse is, always has been, and we believe always will be, "an engineer's company."

Westinghouse

"An Engineer's Company," Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa.

Copr. 1942, Westinghouse Electric & Manufacturing Co.

Whatever the Key...



They Practice Imagineering Here

We've been counting noses here at Alcoa, and we were amazed to discover the variety of Keys dangling from watch chains around here.

Keys don't make the man. We mention them only as a handy way of getting at the interesting fact that it takes all kinds of men and *of knowledge* to make an organization, such as Alcoa, tick.

The striking thing is, how soon most of our men shed their specific labels after they come with us only to discover how much more *exciting* it is to practice Imagineering.

There aren't any grooves to Imagineering. There aren't any limits, either. A man lets his imagination soar and then engineers it down to earth. When he comes down he is just as liable to find himself in a new department, with new responsibilities, and a new set of conditions on which to practice his Imagineering.

It is this kind of thing going on continuously for fifty years that has made Alcoa a useful business and an exciting organization in which to be.

It is what the future of Aluminum is made of.

ONE PAGE FROM THE AUTOBIOGRAPHY OF

ALCOA ALUMINUM

• This message is printed by Aluminum Company of America to help people to understand *what we do* and *what sort of men* make aluminum grow in usefulness.

SAMSON SPOT SASH CORD

Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish.
The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes; also cotton twines.

CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS — **89 Broad Street, Boston 9, Mass.**

ELECTRICAL ENGINEERING

(*Continued from page 54*)

in their motion (Fig. 6); absorption spectra and phosphorescence are evidence of electron trapping and release; admixtures are introduced to change the coupling between electron and structure.

These experiments again begin to throw new light upon other questions tantalizing the profession. How can insulators be improved? Why do dry rectifiers rectify? Can solar energy be economically transformed into electric power by new types of photocells? Well, we are trapped in a vicious cycle, between questions asking for new experiments and experiments raising new questions which will keep busy our own generation and some to come. In the end we shall get our atomic theory of electrical engineering, but only — as we have learned today — if we fight our own battle.

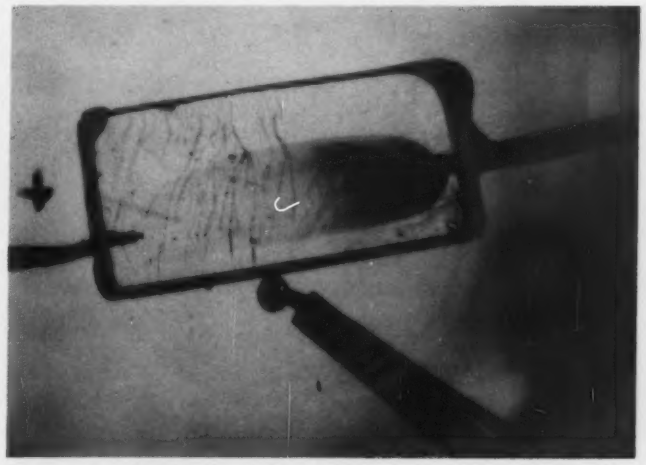


Figure 6. Dark cloud of electrons streaming through a rock salt crystal from cathode towards anode

Figure 5. Spark landscape in nitrogen. (Electrode negative 16 atmospheres, 30 KV)

IBM REPRODUCER

(*Continued from page 64*)

In view of the fact that the punching mechanism of the Reproducer, which now operates 14 times per cycle, is already operating as fast as is considered practicable with the present design, it was necessary to devise other means for changing the printing cycle. It was finally decided to superimpose a longer cycle which would be utilized solely as the basic timing for the printing mechanism.

Cards are passed through the machine top edge foremost, the order of sensing perforations being 12, 11, 0, 1, 2, 3, . . . 9. The 12 and 11 holes are special perforations which are not sensed for printing, and as only the 10 rows of holes from 0 to 9 inclusive must be sensed for printing, it was decided to sense the first holes — the 0's, 1's, 2's, 3's and 4's, and to enter these perforations into some form of storage device from which they might be fed back to control the printing mechanism during the latter part of the cycle.

This arrangement was chosen as the basis for the design, with the result that the machine was permitted to function for punching on a 14-point cycle without any sacrifice in speed.

The impulses from the first five rows of holes in the card were entered into a storage mechanism and corresponding impulses were fed from this storage mechanism to the type wheel control magnets at a later time in each card cycle. These impulses are interspersed in time value with normal impulses sensed at the master card. The net effect of this combination of timing was to permit the use of a relatively simple type of relay "storage" circuit without resorting to combination circuits and the attendant complicated coding and decoding devices. The (*Continued on page 72*)

HOW TO SEE RED...AND LIKE IT!

Friction . . . arch enemy of *speed* in the machining of iron and steel . . . meets its match in cutting tools made of Haynes Stellite non-ferrous alloys. For these alloys . . . of cobalt, chromium, and tungsten . . . have the amazing property of "red hardness." Unlike cutting tools made of ordinary metals, they *keep their edge* . . . and keep on cutting . . . even when friction heats them *red hot.*

Making possible tougher, longer-lasting cutting tools is only one of the vital roles played by Haynes Stellite materials. Because they stand up under heat, abrasion, and corrosion, they are used to hard-face many different kinds of metal parts.

Oil well drilling bits . . . steam shovel bucket lips . . . heavy gears . . . shafts . . . airplane and truck exhaust valve seats . . . crusher blades . . . mixers . . . plowshares . . . and other pieces of equipment that must withstand steady punishment have their lives lengthened . . . and their efficiency stepped up . . . with welded-on hard-facings of Haynes Stellite alloys.

Use of Haynes Stellite alloys speeds up production . . . lowers production costs . . . saves on tool and part replacements . . . reduces time lost while replacements are being made. In the fabrication of new parts, base metals can be selected for such valuable properties as strength and ductility – without particular regard for wear-resistance – because they can then be armored against abrasion, heat, and corrosion by hard-facing with Haynes Stellite alloys.

Further savings can be made by the use of these alloys because worn parts can be *renewed,* instead of being sent to the scrap pile . . . thus eliminating replacement with materials hard to obtain.

Faster production . . . conservation of metals . . . lower costs . . . these are the contributions made to industry by Haynes Stellite alloys.

• • •

The development of Haynes Stellite Company alloys and hard-facing practice has been furthered by the metallurgical knowledge of Electro Metallurgical Company, by the research facilities of Union Carbide and Carbon Research Laboratories, Inc., and by the service organization of The Linde Air Products Company – which companies also are Units of Union Carbide and Carbon Corporation.

HAYNES STELLITE COMPANY

Unit of Union Carbide and Carbon Corporation

KOKOMO, INDIANA UCC NEW YORK, N. Y.

GTD

What is the Significance of this Mark?

FOR over 30 years this trademark has appeared on every screw threading tool and screw thread gage manufactured by Greenfield Tap And Die Corporation. Guess—if you do not know—its significance. Then turn this page upside down and see if your guess is correct.

GREENFIELD TAP AND DIE CORPORATION
GREENFIELD, MASS., U. S. A.

GTD GREENFIELD
TAPS · DIES · GAGES · TWIST DRILLS · REAMERS · SCREW PLATES · PIPE TOOLS

The outline of the trademark is the exact outline of a perfect "National Form" screw thread, walls, root, crest, etc. The letters are the company's initials. You can rely on threads cut by tools with this mark.

FRANKLY SPEAKING

(*Continued from page 62*)

of the Industrial Relations section. Founded six years ago, this section now numbers nine instructors and research men. In the past year alone at least six new courses have been added, and registration has jumped in some classes by 300 per cent. Incidentally, this section is being financially supported largely by contributions from far-sighted industrialists who see the value of such training.

Some students, notably members of the Debating Society, are demonstrating an interest in labor relations in their extra-curricular activities.

We feel that all this new student interest is good and very much to the point. Tech students for their own sake should be at least acquainted with labor problems. After all, 60 per cent of M.I.T.'s graduates hold executive positions within ten years of graduation. Engineers should be educated not only on technical matters; they should have some knowledge of pertinent business problems. A college graduate today has a tremendously greater opportunity to advance in industry if he knows how to face labor problems. Only if a technician spends his entire life in the laboratory can he safely omit the study, formal or haphazard, of industrial relations.

WAR PRODUCTION

No longer are we interventionists, isolationists, capitalists, laborers, Republicans, or Democrats, but 130,000,000 citizens of the United States united in grim determination to eliminate once and for all time the totalitarian philosophy that threatens to destroy civilization. There can be but one answer to this threat — total victory over the forces of the Axis.

To attain victory it is necessary that industry furnish quickly in tremendous quantities the sinews of war. There must be no hysteria, but instead, an uninterrupted and ever-increasing flow of materials so that our armed forces will be adequately equipped for the hard task that lies ahead. More and more non-defense industries are experiencing difficulties in obtaining materials. Everyone is affected by shortages of rubber and sugar. Such hardships may be annoying but the vital task ahead justifies any curtailment that is asked or demanded.

For the first time in several decades we face serious shortages. The belief that the United States is the land of plenty has been altered to meet the existing situation. We must school ourselves to conserve, even in the most minute detail; we must learn how to utilize over and over again the supplies on hand; we must find ways and means of allocating what we have in such a manner that the maximum in the way of production is assured. The final advent of war may be a blessing in disguise if it lifts us out of our lethargy and smug complacency; if it teaches us to take nothing for granted.

This is an industrialized war in which the worker is as important as the soldier. Everyone can serve best by doing his job better, more thoroughly, and by giving more time and effort to it. The enemy would like to create panic and disorder — if we remain cool and keep our determination, we can achieve the gigantic industrial output necessary to win this war.

IBM INTERPRETING REPRODUCER

(*Continued from page 69*)

perforations 5, 6, 7, 8, and 9 are sensed by the brushes to control directly the type wheel magnets, and the interposed impulses from the storage device provide the necessary control impulses for the digits 1, 2, 3, 4, and 0 (Fig. 5). This necessitated a special arrangement of characters on the rim of the type wheel, the order of such characters being 5, 1, 6, 2, 7, 3, etc., the 0 being the last digit sensed (see Figs. 4 and 5).

It was noted above that there were two reasons for desiring a change in cycle, and that one of these reasons was to reduce the shock which would have been encountered in restoring type wheels to 0. The other of these reasons is to provide additional time for the travel of the card so that it may be positioned in a suitable relationship to provide for printing the numbers in a center location at the end of the card; and this, in turn, required feeding the card several additional steps after the corresponding master card has been completely sensed.

The timing of the print wheel drive cams and associated mechanism was designed to provide several additional steps of movement for the card between the time in the cycle when the type wheels are positioned and the time when the actual printing is effected. Thus the actual printing is effected at a time in the machine cycle when the machine is already sensing the succeeding card and punching the second succeeding card.

Thus it will be seen that the machine is performing three different functions on three different cards, and each card as it passes through the machine will be punched during one cycle, sensed during a second cycle, and printed during a third cycle; and during each of these operations the machine will be performing other operations on other cards. This overlapping of cycles has made it possible to maintain a relatively high speed of output as expressed in cards-per-minute.

The card production of the machine would have been only one-third as great if it were necessary to perform

Figure 7. High speed platen bail operating parts

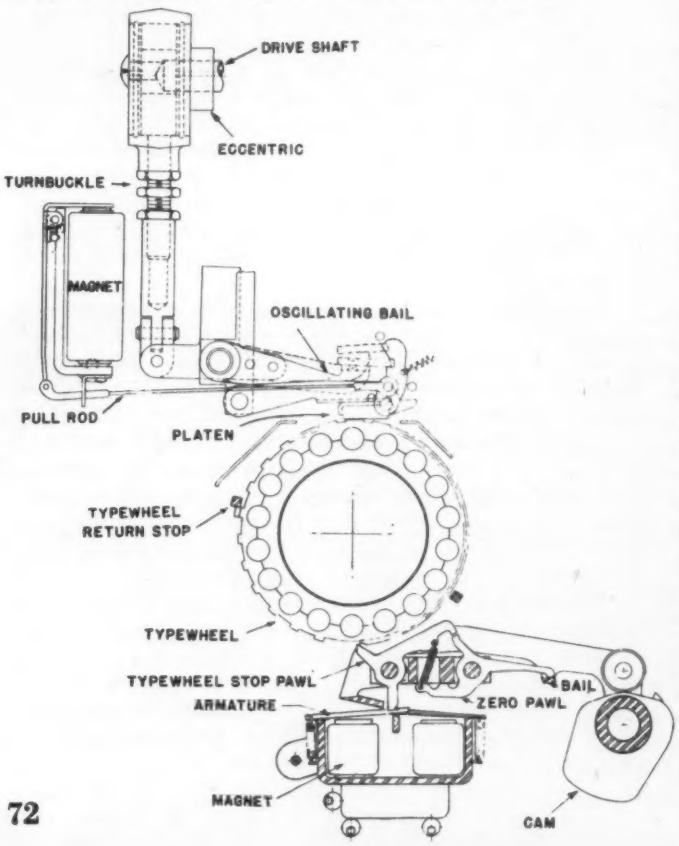


Figure 8. Ink ribbon is easily replaced

these operations in sequence upon each card before starting another series of operations on another succeeding card. The operation of the machine might be compared generally to the operation of a multiple spindle automatic screw machine with which the reader may be somewhat more familiar.

International Business Machines Corporation has always devoted considerable attention to the problem of mechanically servicing and automatically lubricating its machines. The various mechanisms of the machine are designed in the form of units which may be readily removed for inspection or replacement of worn parts. The Interpreting Reproducer is a good example of design effort along this line. The interpreting unit is completely self-contained and is arranged so that it may be shifted part way out of the machine to facilitate replacement of the ink ribbon or cleaning of the unit, as in Figure 8.

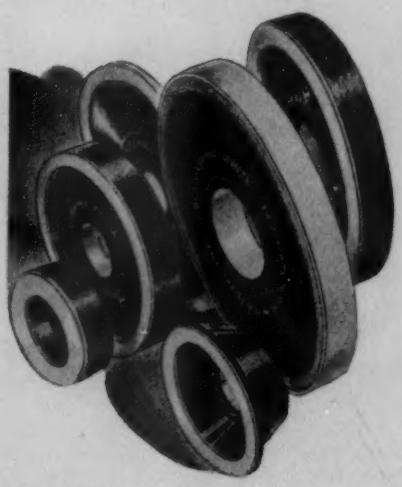
The interpreting unit is located at a point in the machine below the card line where there is a considerable accumulation of card dust and lint which accumulates in considerable quantity after the passage of millions of cards through the machine. The printing unit is provided with a complete auxiliary housing to protect the mechanism from this card dust.

Automatic lubrication has been provided for the entire machine and various types of lubricating devices have been provided according to the requirements of each unit. The interpreter unit type wheels are operated only 100 times per minute, and it was not necessary to supply force-feed lubrication to these operating parts. Oil-less bearings were provided for the camshaft and printing wheel shaft. The print wheel assembly is designed to provide an oil reservoir inside the sleeve supporting the print wheels. This space is plugged with waste and may be filled with oil to supply type wheel lubrication for six months of normal use.

Can you find the Weapon of War in this picture?

This is a war of machines. And one of its decisive battles is being fought in the tool rooms of America — with diamonds as weapons! For the high speed production of alloy steel parts depends on cemented carbide cutting tools. Tools so hard that only diamonds can give them the fine, true edge necessary for efficient cutting. Thus Carborundum Brand Diamond Wheels are playing a vital part in helping America re-arm.

Because these cutting tools are the hardest known, sharpening and conditioning them posed a special problem. Carborundum solved it by developing a grinding wheel made of crushed South African diamond bort. With this wheel, cemented carbide tools can be finished to a better, truer longer-lasting edge in a fraction of the time formerly required.



Development of new abrasive products to meet new needs is an old story with Carborundum. This "know how" is now speeding up thousands of defense jobs. The Carborundum Company, Niagara Falls, New York.

CARBORUNDUM
REG. U.S. PAT. OFF.
ABRASIVE PRODUCTS

Carborundum is a registered trade-mark of and indicates manufacture by The Carborundum Company.

G-E Campus News

NAVY CLASSROOM

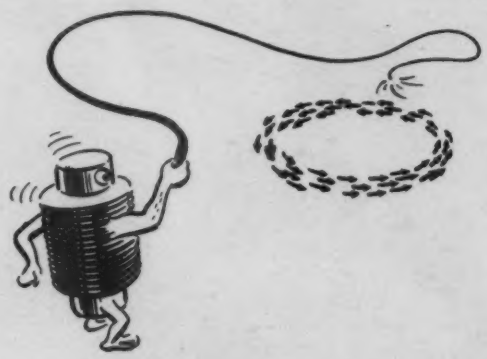
A U.S. submarine is essentially an electric-propelled vehicle, and an amazing amount of electric equipment is packed away in its steel hull. Responsibility for operation, maintenance, and repair of all this electric equipment is in the hands of two classes of petty officers—chief electrician's mates and electrician's mates first class.

For years General Electric has collaborated with the Navy in providing instruction for such men. They are shown how all kinds of equipment aboard their ships is built and assembled. Thus petty officers are better qualified both to care for electric propulsion and other apparatus in normal service and to repair it in case of emergency. This training has lately been accelerated. G-E plants are seldom without groups of these visiting Navy men, and in the past two years more than 50 petty officers have taken the "course."

100 TIMES TOO BRIGHT

IN the early days of electric lights, economical city fathers used to turn out the street lamps on nights when there was a full moon. For the best blackout techniques today, even moonlight is 100 times too bright. But although air-raid wardens can't do anything about the moon, for overcast nights General Electric's illuminating laboratory has developed a special street light which produces illumination about equal to starlight.

The fixture contains a 10-watt lamp, so concealed that the only light visible comes through a circular narrow piece of plastic around the side. A projecting black canopy screens the light from the eyes of aviators. The light output, equivalent to that from a single candle flame, seems at first sight to be practically zero. But after a little time eyes become adjusted, as they do in a movie theatre, and objects can be dimly seen 30 to 40 feet away. Specifications for the new lamp are based on the experience of the British in their blackouts.



ELECTRON WHIRLIGIG

WHETHER you call it a "rheotron" or "betatron" or by its longer name of "induction electron accelerator," a new science tool recently built by Dr. Donald W. Kerst in the G-E Research Laboratory is one of the world's most potent merry-go-rounds. On it, electrons ride to a speed closely approximating that of light — equivalent to that produced by 20 million volts. Copper bombarded by these dizzy, super-speed electrons becomes temporarily radioactive, and other interesting possibilities are being investigated.

Dr. Kerst, young professor at the University of Illinois, got the idea for the device, built a small model, and came to General Electric to build a bigger one. Like the much-publicized cyclotron, except that it accelerates electrons instead of positive ions, the device chases the charged particles round and round in a magnetic field, adding to their speed at every revolution. Scientists are reticent about predicting what the rheotron's chief use will be, but it is promising enough so that a bigger one is being built in the G-E laboratory for speeds of 100 million volts.

GENERAL ELECTRIC

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Kendall Square, Cambridge